DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
George K. Burgess, Director

DEVELOPMENT OF THE STANDARD NUMBERED COTTON DUCK SPECIFICATION

STUDY OF METHODS OF TESTS AND TOLERANCES

By Charles W. Schoffstall and Russell T. Fisher

TECHNOLOGIC PAPERS OF THE BUREAU OF STANDARDS, No. 264

DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
George K. Burgess, Director

TECHNOLOGIC PAPERS OF THE BUREAU OF STANDARDS, No. 264
[Part of Vol. 18]

DEVELOPMENT OF THE STANDARD NUMBERED COTTON DUCK SPECIFICATION

STUDY OF METHODS OF TESTS AND TOLERANCES

BY

CHARLES W. SCHOFFSTALL, Associate Physicist
RUSSELL T. FISHER, Associate Technologist
Bureau of Standards

SEPTEMBER 26, 1924

PRICE, 10 CENTS
$1.25 PER VOLUME ON SUBSCRIPTION
Sold only by the Superintendent of Documents, Government Printing Office
Washington, D. C.

WASHINGTON
GOVERNMENT PRINTING OFFICE
1924

DEVELOPMENT OF THE STANDARD NUMBERED COTTON DUCK SPECIFICATION

STUDY OF METHODS OF TESTS AND TOLERANCES

By Charles W. Schoffstall and Russell T. Fisher

ABSTRACT

This investigation was carried on by the Bureau of Standards in cooperation with the Cotton Duck Association through its technical committee.

A study of various samples of numbered duck, ranging for the medium texture from 2/0 to 6, and for the hard texture from 2/0 to 12 was made. The various test methods are shown. For breaking strength, the strip and three types of grab methods were used, 1 by 1 by 3 inches, 1 by 2 by 3 inches, and 1 by 1 by 1 inch. The 1 by 1 by 3 inch grab method was selected for the standard breaking-strength method of test. The results are listed in construction and breaking-strength tables with various graphs to illustrate the significance of the data. The study of the results shows how the specifications were formulated. There is given the final specification for numbered cotton duck.

CONTENTS

I. INTRODUCTION

Numbered duck may be defined as a mechanical cotton fabric, plain weave, made from heavy plied yarns.[1] The number of the duck is based on the following computation:[2]

Number of duck = 19 − (Weight per linear yard 22 inches wide in ounces)

[1] This definition is given as an aid to the reader, and may or may not coincide with the final agreement on a definition for this material by a joint committee from the Cotton Duck Association and the National Association of Tent and Awning Manufacturers.

[2] When the weight per linear yard exceeds 19 this number is indicated as follows: 19 ounces per linear yard is numbered 1/0, 20 ounces is 2/0, etc.

Numbered duck is commercially designated as either soft, medium, or hard texture. The texture of the duck is dependent on the number of filling threads per inch, the hard texture having more threads than the medium or soft, and the medium more threads than the soft.

While numbered ducks are manufactured ranging in weights from 11 to 49 ounces per square yard (7 to 30 per linear yard 22 inches wide), those most commonly used, especially by the Government departments, range from 11 to 33 for the hard texture and 21 to 33 ounces per square yard for the medium texture.

Numbered duck has a great variety of uses. Some idea of the importance of this fabric may be had by considering the following list, which includes some of the more important uses in the Government services: Covers for pontoons; tarpaulins; cots; parts of tents, such as flaps, ventilators, etc.; wind sails; canopies; winch covers; hammocks; coaling bags; clothes bags; awnings; canvas bands for flags, etc. It lends itself easily to waterproofing on account of its close texture. In addition, it has unusual wearing qualities, probably because of this close texture and comparatively heavy weight.

REASONS FOR THE INVESTIGATION

Notwithstanding the fact that the term "numbered duck" has been definitely established in the industry to mean a certain type of fabric, there have been at various times numerous different specifications used to cover the qualities of this material. Especially was this a fact in the Government service. It was this state of affairs which led the Cotton Duck Association to request this bureau to investigate the characteristics of the commercial numbered ducks for the purpose of establishing specifications which would be acceptable to manufacturer and consumer. These specifications would be the standard throughout the cotton-duck industry, since they would be the product of the cooperative efforts of the Cotton Duck Association representing the manufacturers, and the representatives of various Government departments representing the users. The Bureau of Standards obtained and collated the technical data as set forth in this paper.

II. PURPOSE OF THE INVESTIGATION

The purpose of the investigation was to study various commercial numbered ducks in order to formulate and establish specifications for numbered cotton duck for adoption both for Government use and by the industry.

III. COLLECTION OF SAMPLES AND AVAILABLE DATA

This investigation was begun with a conference of representatives from the Cotton Duck Association, Quartermaster Corps of the War Department, Bureau of Construction and Repair of the Navy Department, Panama Canal, and Bureau of Standards in August, 1921, at which time there was submitted a proposed draft of specifications based on available information and some tests on commercial fabrics. At this meeting plans were made for the submission of samples and other data by the members of the Cotton Duck Association, and a review of the existing specifications. The only method of test on which there seemed to be no definite agreement was the one on breaking strength. To arrive definitely at some decision it was planned to study the results obtained using several different methods.

IV. TEST METHODS

A room equipped with an automatically controlled humidifying and dehumidifying system was used in the conditioning of all samples preparatory to tests. All tests for weight, strength, thread count, twist, etc., were made upon material having a normal moisture content by exposure for at least four hours to an atmosphere of 65 per cent relative humidity at 70° F. temperature. The following test methods were used in this investigation:

1. WEAVE

The determination of the weave is a visual one. This material offered no difficulties, since these fabrics are all plain weave—that is, one up and one down.

2. THREAD COUNT

The number of threads in warp and filling were counted over a space of 3 inches for each sample in five different places. An ordinary thread counter with low-power magnifying glass was used. In counting the warp threads, the spaces were taken equally between the selvages, in no case approaching nearer than 1 inch to the selvage. In counting the filling, the places counted were spaced equally over the entire length of the sample. The thread count for each system was taken as the average of the five separate determinations, calculated on a basis of threads per inch.

3. YARN SIZE

The yarn size of the material was not determined.

4. TWIST AND PLY

Ten threads over 10 inches long were taken from warp and filling, respectively, of each sample. The turns per 10 inches were determined by means of an apparatus which untwists the specimen. This figure was reduced to twists per inch. The average of the 10 determinations was obtained for each system. The ply was determined by counting the individual single yarns.

5. WIDTH

Each sample was laid out flat and measured in three different places as far apart as the sample would permit at right angles to the warp threads by means of a steel tape to the nearest one-sixteenth of an inch. The arithmetical average of these three determinations was taken as the width of the respective sample.

6. WEIGHT

Five specimens, each 2 by 2 inches, were cut from each sample by means of a steel die. Their positions were equally spaced between the selvages, in no case approaching nearer than 1 inch to the selvage, and were staggered along the warp as far as the length of the sample would permit. Each of these specimens was then weighed on a torsional balance, which with a 2 by 2 inch specimen is calibrated to read the weight in ounces per square yard. These five determinations were averaged.

7. BREAKING STRENGTH

There were several methods suggested for breaking strength. Two of these, the 1 by 1 by 3 inch grab method and the 1 by 3 inch strip method, have since been adopted as standard for testing textile materials.[3] In addition to these two, tests were made according to the 1 by 1 by 1 inch and the 1 by 2 by 3 inch grab methods. These methods are as follows.

(*a*) BREAKING STRENGTH, STRIP METHOD.—Ten test specimens approximately 6 inches long by 1¼ inches wide were cut, five in the direction of the warp and five in the direction of the filling, respectively. In the warp direction, the locations of the specimens were spaced equally on each side of the center line running lengthwise; in the filling direction the locations of the

[3] These methods are now included in "Standard Textile Test Methods" as issued by the Bureau of Standards. These have been approved by the textiles committee of the Federal Specifications Board, the Joint Committee on Research and Standardization for the Wool Industry, and the Joint Committee on Standardization and Specifications for the Cotton Industry.

specimens were distributed and staggered as much as the length of the sample would permit. (See fig. 1.) Each specimen was raveled to exactly 1 inch by taking from each side approximately the same number of threads. Care was taken that no two test specimens included the same threads, except for retest as specified below.

The machine used was of the inclination balance type. The capacity of the machine was 800 pounds. The pulling jaw traveled at a uniform rate of 12 inches per minute under no load.

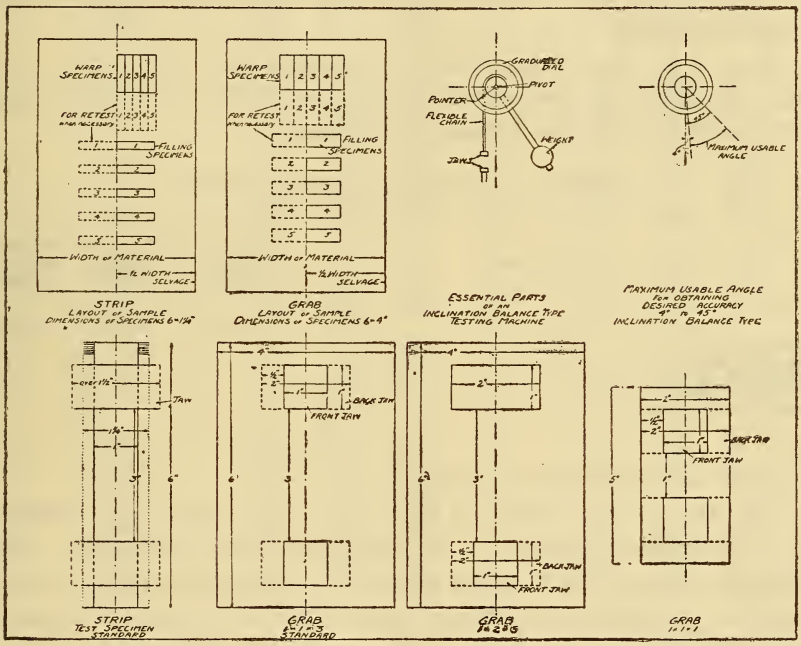

FIG. 1.—*Layout of sample and position of jaws on breaking strength test specimens for all tests used*

Essential parts and limits of use of inclination balance type of machine is shown (upper right). Specimens of the present standard strip and grab methods are indicated.

The distance between jaws was 3 inches at the start of the test. The width of the jaws was 1½ inches or more. The jaws had a smooth, flat surface with edges slightly rounded to prevent cutting. The results of the tests for each direction were averaged. When a specimen slipped in the jaw, broke in the jaw, broke at the edge of the jaw, or for any reason due to faulty operation the result fell markedly below the general average, the result was disregarded, another specimen taken from the same threads, and the results of this break included in the average.

(*b*) Breaking Strength, 1 by 1 by 3 Inch Grab Method.—Ten test specimens 6 inches long by 4 inches wide were cut, five in the direction of the warp and five in the direction of the filling, respectively. Care was taken that no two test specimens included the same threads, except for retest as specified below. The locations of the specimens were determined as in the strip method. (See fig. 1.)

The machine used was similar to that used in determining the breaking strength by the strip method, except that the bottom half of the jaw was 2 inches or more in width and the other half 1 inch in width.

The 1 by 2 by 3 inch grab method and the 1 by 1 by 1 inch grab method were performed essentially as the 1 by 1 by 3 inch grab method with the following variations:

TABLE 1.—Variations in Grab Methods

Width of jaws	1 by 1 by 3 inch grab method	1 by 2 by 3 inch grab method	1 by 1 by 1 inch grab method
	Inches	Inches	Inches
Fixed jaw, top	1	2	1
Fixed jaw, bottom	2	2	2
Pulling jaw, top	1	1	1
Pulling jaw, bottom	2	2	2
Distance between jaws	3	3	1

These are illustrated in Figure 1.

The size of the sample of the 1 by 1 by 1 inch grab method is 5 by 2 inches instead of 6 by 4 as in the other two cases. This method was not tried in the general investigation, but was used later in a special run to compare results from it with those obtained from the strip and the 1 by 1 by 3 inch grab methods.

V. RESULTS OF TESTS

TABLE 2.—Construction Table for Medium-Texture Duck

Number of duck	Code mark	Width	Weight per square yard	Weight per linear yard [1]	Ply		Twist of ply per inch		Threads per inch	
					Warp	Filling	Warp	Filling	Warp	Filling
		Inches	Ounces	Ounces						
2/0	AM1	22 1/8	32.1	19.6	5	8	4.64	2.73	30	16 1/2
	BM1	22 1/4	30.8	18.8	5	8	4.84	2.15	30 1/2	16 1/2
	DM1	14 9/16	32.9	20.1	6	8	4.08	3.98	26	16 1/2
1/0	AM2	22 3/16	30.4	18.6	5	7	4.42	1.30	30	17
	BM2	22 1/4	29.5	18.0	5	7	4.73	3.06	30	16 1/2
	DM2	14 7/16	30.7	18.8	6	7	4.11	3.17	26	17 1/2
	EM1	22 1/16	30.4	18.6	5	7	4.90	2.80	32 1/2	16 1/2
	FM1	36 1/4	30.3	18.5	5	7	4.80	2.90	32	17
1	AM3	22 1/8	29.1	17.8	5	6	4.36	2.31	30	17 1/2
	BM3	22 1/4	28.1	17.2	5	6	4.51	3.20	30	17 1/2
	DM3	22 1/8	28.7	17.5	5	6	4.89	3.71	29	18
	EM2	22 1/4	28.6	17.5	5	6	4.90	3.00	31	17 1/2
	FM2	36 1/8	29.0	17.7	5	6	4.70	2.80	31	18
2	AM4	22 1/4	27.3	16.7	5	6	4.63	2.26	28 1/2	16 1/2
	BM4	22 3/16	26.9	16.4	5	6	4.88	3.33	28 1/2	17 1/2
	DM4	22 3/8	26.9	16.4	5	6	4.93	3.79	26 1/2	18
	EM3	22 1/16	27.1	16.6	5	5	4.90	2.80	28	17
	FM3	36 1/4	27.5	16.8	5	6	4.60	3.40	28	18
3	AM5	22 1/8	26.1	15.9	4	6	5.34	2.09	30 1/2	18 1/2
	BM5	22 3/16	25.5	15.6	4	6	5.22	3.07	30 1/2	17
	DM5	22 5/16	25.9	15.8	5	5	4.82	4.33	26 1/2	19
	EM4	22 1/4	25.5	15.6	4	6	5.90	2.80	29	19
	FM4	36 5/16	25.3	15.5	4	6	3.50	2.60	29	19 1/2
4	AM6	22 1/16	24.7	15.1	4	5	5.31	2.29	30 1/2	19
	BM6	22 1/16	24.2	14.8	4	5	5.25	3.27	31	19
	DM6	14 3/16	24.9	15.2	4	5	4.97	4.51	29	21
	EM5	22 1/4	24.0	14.7	4	5	5.70	2.80	29 1/2	21
5	AM7	22 1/4	23.0	14.1	3	5	6.63	2.69	36	21
	BM7	22 3/16	23.6	14.4	3	5	7.00	3.33	36	20 1/2
	DM7	14 1/8	22.7	13.9	4	4	5.16	6.07	29 1/2	21
	EM6	22 1/8	22.5	13.8	3	5	7.80	2.90	36	21
	FM5	36 5/16	22.5	13.8	3	5	7.60	2.70	35 1/2	20
6	AM8	22 3/16	21.7	13.3	3	4	6.60	3.67	35 1/2	21
	BM8	22 1/4	20.9	12.8	3	4	7.14	3.87	36	21
	DM8	13 7/8	20.6	12.6	3	4	6.52	6.15	34	22
	EM7	22	20.8	12.7	3	3	7.60	3.40	36	26 1/2
	FM6	36 1/4	21.6	13.2	3	3	7.50	7.10	35 1/2	26 1/2

[1] Based on 22-inch width.

TABLE 3.—Breaking Strength of Medium-Texture Duck

Number of duck	Code mark	Strip method		Grab method, 1 by 1 by 3 inch		Grab method, 1 by 2 by 3 inch		Strength-weight factor [1]	
		Warp	Filling	Warp	Filling	Warp	Filling	Strip	1 by 1 by 3 inch grab
		Pounds	Pounds	Pounds	Pounds	Pounds	Pounds		
2/0	AM1	267	383	546	471	564	534	20.5	31.7
	BM1	250	350	442	419	528	506	19.5	27.9
	DM1	281	338	516	474			18.8	30.1
1/0	AM2	282	320	517	444	566	477	19.8	31.6
	BM2	263	291	443	578	518	434	18.8	27.8
	DM2	293	318	525	419			19.8	30.7
	EM1	261	307	540	404	526	440	18.7	31.0
	FM1	275	306	514	419	527	449	19.0	30.3
1	AM3	290	292	495	366	538	403	20.0	29.6
	BM3	268	274	463	350	518	387	19.3	28.9
	DM3	236	321	469	414			19.4	30.8
	EM2	265	274	504	375	558	420	18.8	32.4
	FM2	257	315	487	378	535	432	19.7	29.8
2	AM4	280	270	466	340	507	365	20.2	29.5
	BM4	259	294	463	341	493	377	21.0	29.9
	DM4	244	308	447	377			20.3	30.6
	EM3	242	280	464	385	495	419	19.3	31.3
	FM3	246	302	463	392	516	416	19.9	31.1
3	AM5	226	321	376	393	435	436	21.0	29.5
	BM5	250	272	387	327	434	382	20.7	28.0
	DM5	262	265	433	354			20.2	30.4
	EM4	190	309	390	411	416	473	19.6	27.1
	FM4	211	311	400	422	462	473	20.3	32.5
4	AM6	238	278	391	337	442	356	20.9	29.5
	BM6	251	271	402	311	462	354	21.6	29.5
	DM6	230	285	425	402			20.3	33.2
	EM5	228	265	401	343	448	397	20.5	31.0
5	AM7	196	285	320	341	378	385	20.9	28.7
	BM7	191	295	322	387	351	401	20.6	30.0
	DM7	243	223	417	301			20.3	31.7
	EM6	209	300	374	366	391	398	22.6	32.9
	FM5	194	271	359	372	404	384	20.3	32.5
6	AM8	197	238	322	267	355	302	20.0	26.9
	BM8	202	211	309	255	342	265	19.7	27.0
	DM8	192	230	307	289			20.2	29.0
	EM7	204	300	398	352	418	343	20.4	36.0
	FM6	202	229	369	296	413	320	20.0	30.8

[1] See p. 460 for definition.

TABLE 4.—Construction Table for Hard-Texture Duck

Number of duck	Code mark	Width	Weight per square yard	Weight per linear yard[1]	Ply		Twist of ply per inch		Threads per inch	
					Warp	Filling	Warp	Filling	Warp	Filling
		Inches	Ounces	Ounces						
2/0	AH1	22 1/8	31.5	19.2	5	7	4.4	2.7	30	18 1/2
	BH1	22 3/16	30.3	18.5	5	7	4.7	3.1	30 1/2	18 1/2
	DH1	17 5/8	32.3	19.7	6	7	4.1	1.6	26	18 1/2
1/0	AH2	22	30.8	18.8	5	6	4.6	3.0	30 1/2	19 1/2
	BH2	22 1/4	29.4	18.0	5	6	4.8	3.1	30	19
	DH2	14 3/16	30.2	18.5	6	6	4.2	3.3	26	18 1/2
1	AH3	22 1/16	29.3	17.9	5	5	4.6	3.5	30 1/2	20 1/2
	BH3	22 1/8	27.6	16.9	5	5	4.9	3.2	31 1/2	19 1/2
	DH3	14 7/16	28.0	17.1	5	6	5.0	4.4	26 1/2	20
2	AH4	21 15/16	27.8	17.0	5	5	4.5	1.8	29	21 1/2
	BH4	22 1/4	28.1	17.2	4	5	4.8	3.2	29	22 1/2
	DH4	14 3/8	26.2	16.0	5	5	5.1	4.6	27	21 1/2
3	AH5	22	26.0	15.9	4	5	5.3	2.9	31	22
	BH5	22 1/8	25.8	15.8	4	4	5.1	3.2	30 1/2	21
	DH5	14 1/4	25.2	15.4	4	5	5.2	4.5	29	22
4	AH6	22 1/2	24.2	14.8	4	4	5.5	3.7	31	23
	BH6	22 1/8	24.4	14.9	3	4	5.3	3.7	31	22
	CH1	28 3/4	29.3	17.8	4	4	5.5	5.2	29	24
	DH6	14 1/8	24.4	14.9	4	4	5.1	5.4	29	25 1/2
	FH1	36 3/16	24.3	14.8	4	4	5.4	2.4	29 1/2	24 1/2
5	AH7	22 1/8	23.0	14.1	3	4	6.5	3.0	35 1/2	24 1/2
	BH7	22 1/16	22.4	13.7	3	3	7.0	2.7	35 1/2	24 1/2
	DH7	18 1/16	23.0	14.1	3	4	6.6	5.4	34	24 1/2
6	AH8	22 1/8	20.5	12.5	3	3	6.5	3.7	36	25 1/2
	BH8	22 3/16	21.2	13.0	3	3	6.9	4.5	36	25 1/2
	DH8	14 7/16	20.3	12.4	3	3	6.6	6.8	34 1/2	26
7	AH9	22 1/8	19.1	11.7	3	3	8.3	4.1	45	26
	BH9	22 3/8	19.0	11.6	3	3	8.4	4.6	46	26
	DH9	17 3/16	19.1	11.7	3	4	6.5	6.8	36	29 1/2
	EH1	22 3/16	19.6	12.0	3	4	8.0	4.0	36	28 1/2
	FH2	36 1/16	19.5	11.9	3	4	7.9	3.6	35 1/2	28
8	AH10	22 1/4	18.3	11.3	3	3	8.1	3.9	44 1/2	25
	BH10	22 1/8	17.8	10.9	3	4	8.6	3.2	45 1/2	25
	CH2	25 1/8	18.4	11.2	3	4	7.0	5.9	34 1/2	27
	DH10	14 1/2	17.8	10.9	3	3	6.3	8.9	34 1/2	29
	EH2	22 1/8	17.9	10.9	4	4	7.8	3.9	44	29
	FH3	36 1/8	17.9	10.9	3	4	7.6	3.8	33 1/2	28 1/2
9	AH11	22 1/8	16.6	10.1	3	4	9.5	4.8	50	26
	BH11	22 1/2	15.7	9.6	3	4	9.4	3.3	49	25 1/2
	CH3	40 1/2	16.1	9.8	3	4	8.7	3.6	46	31
	DH11	14 1/8	17.1	10.4	3	4	8.0	7.2	45 1/2	30
	EH3	22 3/16	16.6	10.1	3	4	8.7	3.4	45	30 1/2
	FH4	36 5/16	16.1	9.8	3	4	8.2	3.2	45	31
10	AH12	22 1/16	15.1	9.2	3	3	9.4	6.3	49 1/2	32
	BH12	22 5/16	14.9	9.1	3	3	9.9	5.8	49	32
	DH12	14 1/8	14.9	9.1	3	3	8.6	8.8	46 1/2	31 1/2
	EH4	22 1/4	14.8	9.0	3	3	8.3	3.4	45	30 1/2
	FH5	36 5/16	14.7	9.0	3	3	8.6	3.4	45	30
11	AH13	22 3/16	13.2	8.1	3	2	9.6	8.2	49 1/2	34
	BH13	22 3/8	13.4	8.2	3	2	9.4	7.0	49 1/2	34 1/2
	DH13	14 1/2	13.5	8.2	3	2	8.5	14.3	44	35 1/2
	EH5	22	13.0	7.9	3	2	8.4	4.5	45	32 1/2
	FH6	36 3/8	12.8	7.8	3	2	8.2	4.3	45	32
12	AH14	22 1/16	11.8	7.2	2	2	13.9	7.9	60	36 1/2
	BH14	22 3/16	11.3	6.9	2	2	14.7	3.7	61	36
	DH14	22	12.1	7.4	2	2	14.9	14.1	52 1/2	37
	EH6	22 1/4	11.5	7.0	2	2	13.7	4.8	50 1/2	38 1/2
	FH7	36 1/8	11.7	7.2	2	2	13.1	4.6	50	34

[1] Based on 22-inch width.

TABLE 5.—Breaking Strength of Hard-Texture Duck

Number of duck	Code mark	Strip method		Grab method, 1 by 1 by 3 inch		Grab method, 1 by 2 by 3 inch		Strength-weight factor	
		Warp	Filling	Warp	Filling	Warp	Filling	Strip	1 by 1 by 3 inch grab
		Pounds	Pounds	Pounds	Pounds	Pounds	Pounds		
2/0	AH1	294	395	541	499	568	551	21.8	33.0
	BH1	221	375	512	483	524	534	19.8	32.5
	DH1	263	373	513	483			19.7	30.7
1/0	AH2	269	345	532	468	553	481	19.9	31.8
	BH2	238	325	483	404	550	442	19.3	30.2
	DH2	281	309	528	416			19.5	31.2
1	AH3	272	320	538	413	550	410	20.0	32.5
	BH3	263	312	492	369	564	423	20.8	31.2
	DH3	251	302	450	423			19.8	31.2
2	AH4	280	323	536	428	568	441	21.7	34.7
	BH4	228	319	487	446	539	506	19.5	33.2
	DH4	246	280	476	389			20.1	33.0
3	AH5	238	326	444	420	493	438	21.7	33.2
	BH5	225	305	432	402	493	451	20.6	32.4
	DH5	218	308	409	427			20.9	33.2
4	AH6	255	272	443	323	477	343	21.8	31.7
	BH6	235	249	429	321	479	350	19.8	30.8
	CH1	220	269	402	344	429	402	16.8	25.5
	DH6	234	286	420	427			21.3	32.4
	FH1	229	297	460	395	477	464	21.6	35.1
5	AH7	209	294	386	369	410	381	21.9	32.8
	BH7	195	275	353	345	398	366	21.0	31.2
	DH7	196	258	348	330			19.8	29.5
6	AH8	213	214	378	249	421	280	21.2	30.3
	BH8	207	232	332	288	409	323	20.7	29.3
	DH8	208	212	346	280			20.2	30.8
7	AH9	186	207	305	265	349	272	20.6	29.8
	BH9	190	224	307	293	359	313	21.8	27.5
	DH9	224	207	338	256			22.6	21.0
	EH1	208	213	387	257	408	260	21.5	32.8
	FH2	209	212	281	270	416	281	21.6	35.1
8	AH10	190	182	304	242	343	256	20.2	29.8
	BH10	196	194	289	226	352	253	21.9	28.9
	CH2	224	182	350	193	361	229	22.4	29.6
	DH10	225	151	330	183			21.1	28.8
	EH2	190	195	343	274	360	285	21.5	34.4
	FH3	218	187	346	230	394	258	22.6	32.1
9	AH11	170	204	276	241	287	254	22.5	31.1
	BH11	164	177	248	198	293	242	21.7	28.4
	CH3	155	197	257	244	284	248	21.4	31.1
	DH11	175	208	274	273			22.4	32.0
	EH3	176	201	287	278	325	300	22.7	34.0
	FH4	169	205	289	246	308	252	23.2	33.2
10	AH12	185	144	279	179	318	189	21.8	30.4
	BH12	166	148	250	175	316	206	20.8	28.5
	DH12	187	156	275	193			23.0	31.4
	EH4	179	138	282	188	305	192	21.4	32.0
	FH5	181	152	281	190	315	207	22.6	32.0
11	AH13	186	115	281	136	307	137	23.0	31.7
	BH13	168	115	235	125	287	139	21.1	26.8
	DH13	191	123	281	149			23.2	31.8
	EH5	188	115	273	137	309	139	23.3	31.5
	FH6	180	85	266	128	278	130	20.7	30.8
12	AH14	140	119	208	141	227	148	21.9	29.6
	BH14	143	114	192	121	229	141	22.7	27.7
	DH14	141	126	210	157			22.3	30.3
	EH6	127	130	195	158	208	170	22.3	30.7
	FH7	125	137	187	157	198	147	22.4	29.4

VI. DISCUSSION OF RESULTS

1. WEAVE

Numbered duck is a plain woven fabric. A preliminary determination of the crimp on several of the fabrics showed that the warp crimp ranged from 28 to 34 per cent, while the filling crimp ranged from 3 to 4.5 per cent. This high crimp factor in the warp direction had a decided influence in the selection of the breaking-strength method, as will be shown later.

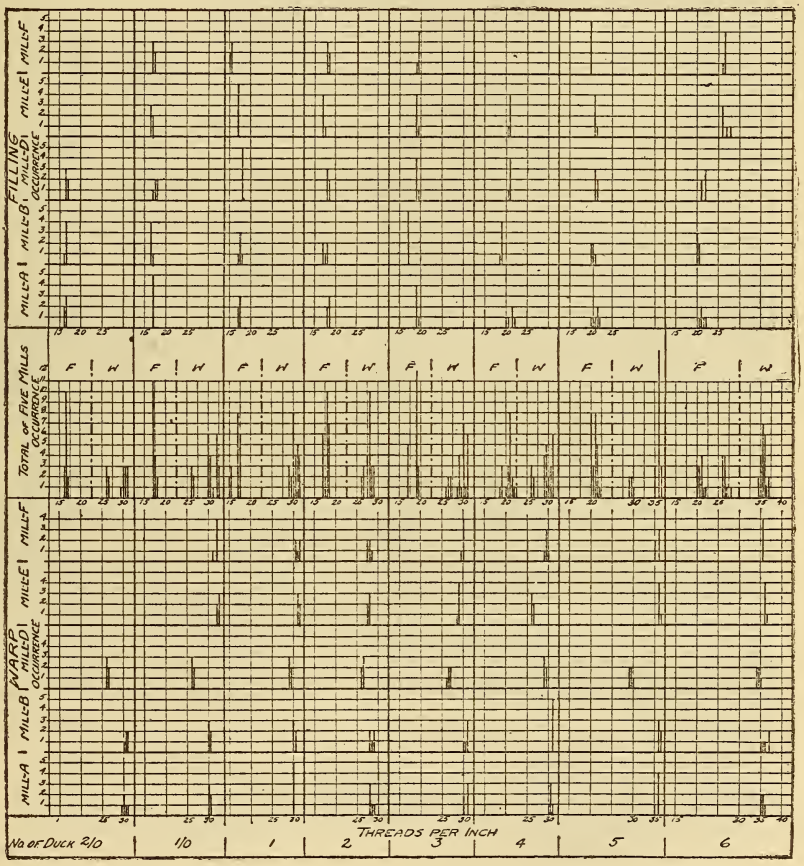

FIG. 2.—*Frequency of occurrence of thread count determinations for various medium texture numbered duck grouped according to mills, separately and combined*

2. THREAD COUNT

Figure 2 shows the frequency of occurrence of the various thread counts for the fabrics of the different mills. It shows that although the thread count for any mill does not vary more than 1 or 2 threads, yet the different mills vary in their construction of fabric having the same number.

Figure 3 shows a study of the thread counts for each number of duck. A gradual trend toward a higher thread count is shown as the number of the duck rises. The range for each number is also illustrated on this graph.

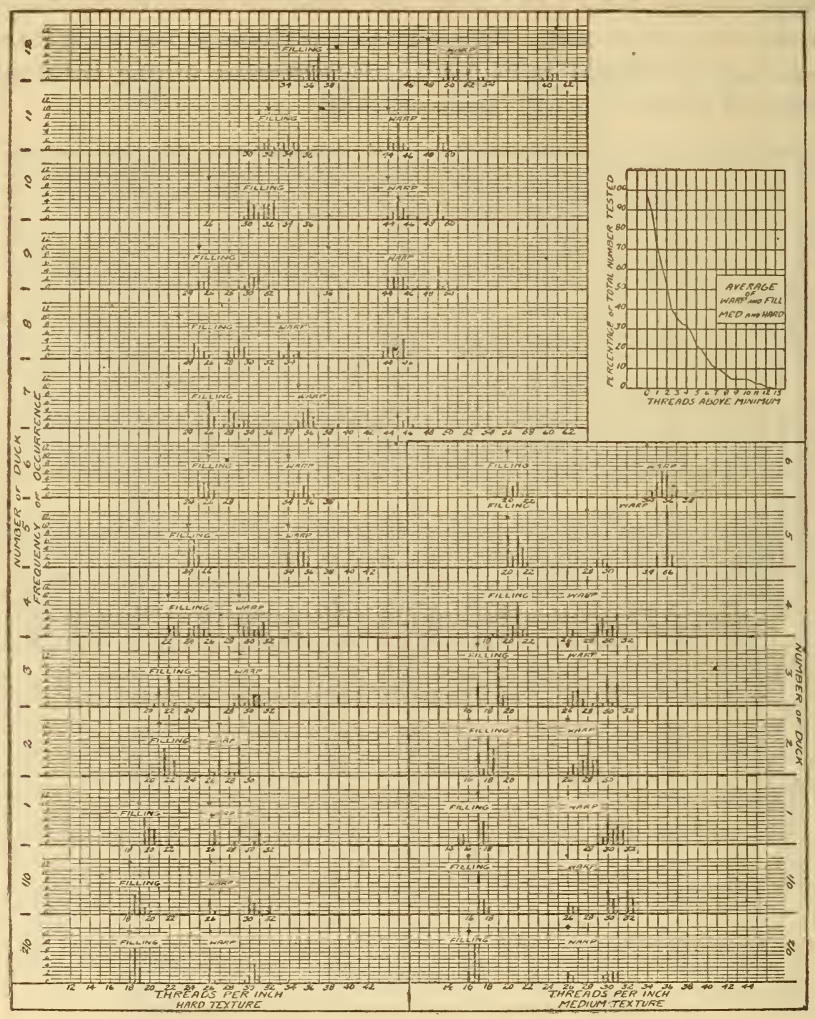

FIG. 3.—*Frequency of occurrence of the average thread count for all mills, grouped according to number for the hard texture and medium texture numbered cotton duck*

The arrows show the minimum thread count adopted for the specification. The curve (upper right shows the percentage of the total number of samples tested at the different number of threads above the specified minimum.

From the results illustrated in Figure 3 the minimum thread count was fixed for the specification. It has been placed for convenient comparison on this graph as indicated by arrows. The curve (upper right) shows that 98 per cent of the duck tested con-

form to this specified minimum thread count. It also shows the various percentages which are 1 or more, 2 or more, 3 or more, etc., threads above the minimum. This method of fixing a minimum permits any manufacturer to exceed it as he desires. However, it is desirable to fix the allowable variation from the manufacturer's established standard. This was ascertained by reference to Figure 2 and similar calculations. It was found that the

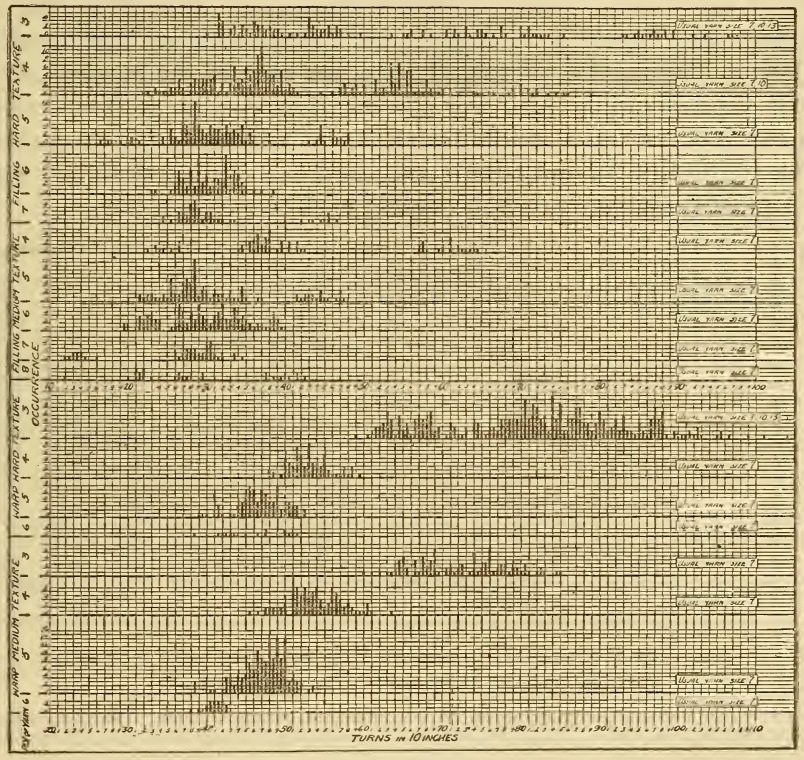

FIG. 4.—*Frequency of occurrence of the ply twist in 10 inches for medium and hard texture numbered duck*

variations in the fabric from the average thread count ranged from 1 to 2 threads.

3. TWIST AND PLY

These data were determined for general information, for it was not thought advisable to hold the manufacturer very strictly to these features, although the minimum ply was put into the final specification. This minimum may be exceeded at the manufacturer's discretion.

Figure 4 shows the ply twist per inch. It indicates a large range of twists with a tendency toward a higher twist as the ply decreased. The wide range was partly due to the different yarn sizes used, especially in the case of the 3-ply. The warp twist was higher than the filling.

4. WIDTH

This material is made in a number of different widths, although the number of the duck has been based on the 22-inch width. All of the fabrics tested in this investigation were 36 inches or under. In Figure 5 is shown the variation from the marked width. The graphs indicate that 80 per cent of the fabrics measured would comply with the specification of plus or minus one-fourth inch variation on materials up to and including 36 inches. The frequency for both hard and medium combined shows that the most frequent variation (mode) is at one-eighth inch.

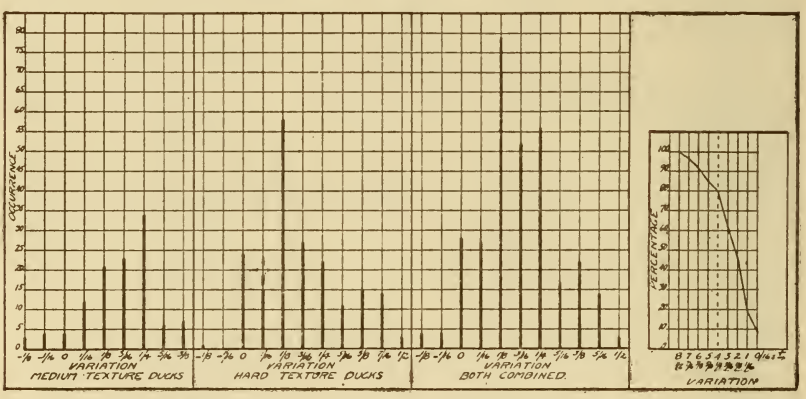

FIG. 5.—*Frequency of occurrence of variations from the marked width of numbered duck for medium texture, hard texture, and both combined*

Curve at right shows the percentage of the total occurring at each point of variation. This graph includes widths up to and including 36 inches for which the tolerance of plus or minus one-fourth inch was fixed.

5. WEIGHT

The weights given in the specification were based entirely on the following calculations:

Weight per linear yard 22 inches wide = 19 − number of duck.

$$\frac{\text{Weight (oz.) per linear yard} \times 36}{\text{Width in inches}} = \text{weight (oz.) per square yard.}$$

Both weights per linear yard and per square yard are given in the specification, but the base used is on the linear-yard figures. This accounts for the figures in the square-yard column in the final specifications given at the end of this paper being expressed to the second decimal place. They have been carried out thus far to take care of the calculations on the allowable tolerances.

This tolerance, which has been fixed at 2½ per cent, is the result of considering the variations in the manufacture of these and other mechanical textile materials. It will be observed by reference to Figure 6 that about 60 per cent of the fabrics studied comply with this requirement. Of the ducks which do not comply, 30 per cent exceed the weight by over 2½ per cent and 70 per cent are underweight.

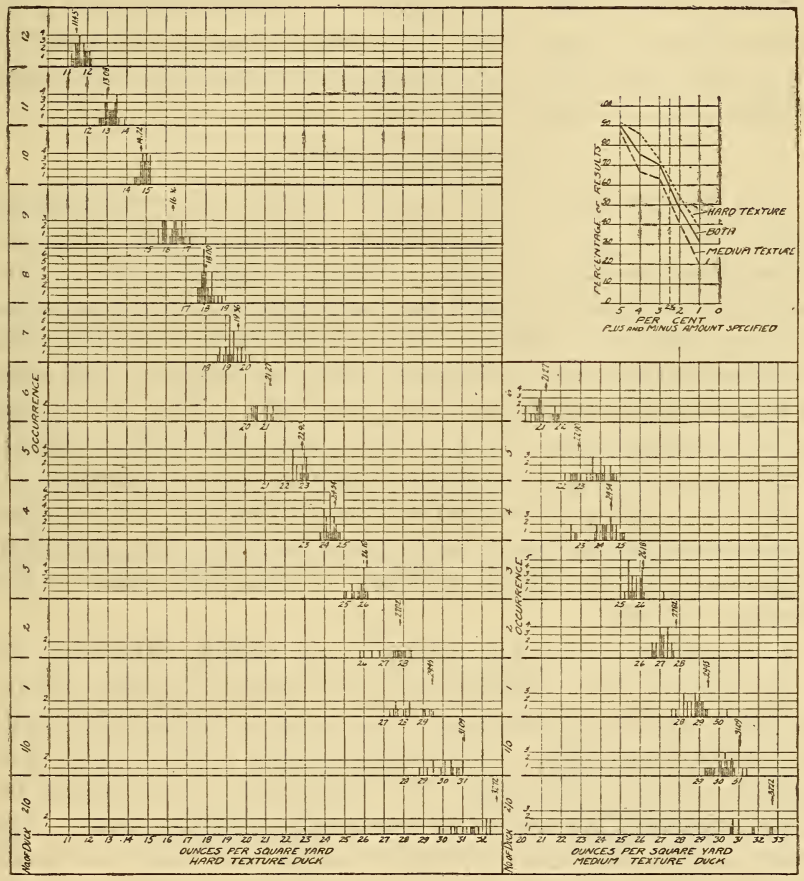

FIG. 6.—*Frequency of occurrence of various weights (ounces per square yard) of hard and medium texture numbered duck*

The percentage of the total occurrence at the various per cent variations from the amount specified is shown.

The results on weight obtained in this investigation, as given in the construction tables, are on the basis of ounces per square yard. The linear results have been calculated.

All Government specifications as they are revised have been and will be on the square-yard basis. The industry has adopted the square-yard basis on all recently developed specifications,

such as tire duck, airplane-wing fabrics, balloon fabrics, dredging sleeves, etc.

Numbered duck as a particular instance shows the results of the linear-yard system. These ducks are quite numerous, some of them are no longer made as a staple, although they would be made on order. Even of those most generally made, the bulk of the purchases falls on less than half the numbers. While first appearing as a 22-inch width fabric, on which the present numbering system is based, they have come into use in many widths; the number, therefore, is of use only to those who are entirely familiar with the type of material.

6. BREAKING STRENGTH

This test presented the greatest number of considerations. There were in use several different methods of test for determining the breaking strength of duck. This resulted in confusion, for since each method produced different results no means of comparison were offered. Accordingly, it was desirable that one standard method be adopted, and to accomplish this a series of tests were run on the prevailing methods. These were stated to be the strip method, the 1 by 2 by 3 inch grab method, and the 1 by 1 by 3 inch grab method. Later in the investigation the 1 by 1 by 1 inch grab method was introduced and a short study made to compare this with the strip and the 1 by 1 by 3 inch grab. The procedure for these methods is described under "Test methods" herein.

A consideration of the methods and results eliminated the 1 by 2 by 3 inch grab method, for it was found that this was not an exact tensile method, since it was a combination of the tearing and breaking strength. The one jaw holding 1 inch of fabric pulls against 2 inches in the other jaw. The yarns held in one and not in the other half are subjected to a modified tearing strain. This combination introduced additional factors, and made the results of little value, since they could not be studied with exactitude. Another consideration which discouraged the adoption of this test was that it was the least used of any of the methods. This was probably due to the reasons given above and hence strengthened the decision to eliminate it.

In the main investigation there remained the 1 by 3 inch strip and the 1 by 1 by 3 inch grab methods. These methods are the most generally used in textile testing.[4]

[4] See footnote 3, p. 446.

Figure 7 shows a comparison of these two methods on the warp direction of medium texture numbered cotton ducks arranged according to numbers and grouped according to mills. It is apparent on this graph that the range for the eight numbers is much larger for the 1 by 1 by 3 inch grab than for the strip. Thus,

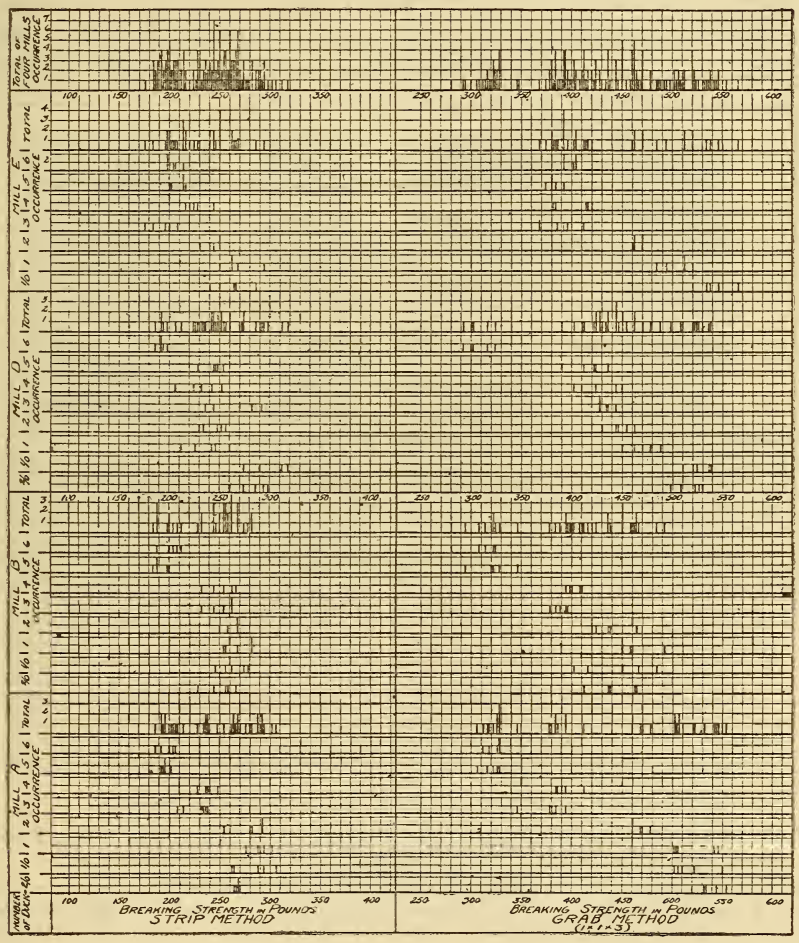

FIG. 7.—*A comparison of the strip and the 1 by 1 by 3 inch grab methods of determining breaking strength*

The frequency of occurrence of results obtained on numbered cotton duck is shown. These two methods are standard breaking-strength methods for woven textile materials.

in the case of the grab method, the results of which range from 270 to 560 pounds, the breaking strength of each of the numbers is more easily defined. The strip method breaks are grouped more closely together and range only from 180 to 320 pounds for the eight numbers of duck shown. In the testing of materials submitted on a contract, or for comparative quality, the more

closely the characteristics can be allocated the more desirable is the test. It is interesting to note in these graphs that the same tendencies are shown by each method; that is, where one of the breaking strengths was low or high in one method a similar tendency was shown by the other method.

Also in the strip method of test it has been found that when the crimp is much higher in one system of threads than the other system, as is the case with numbered ducks, the outside threads

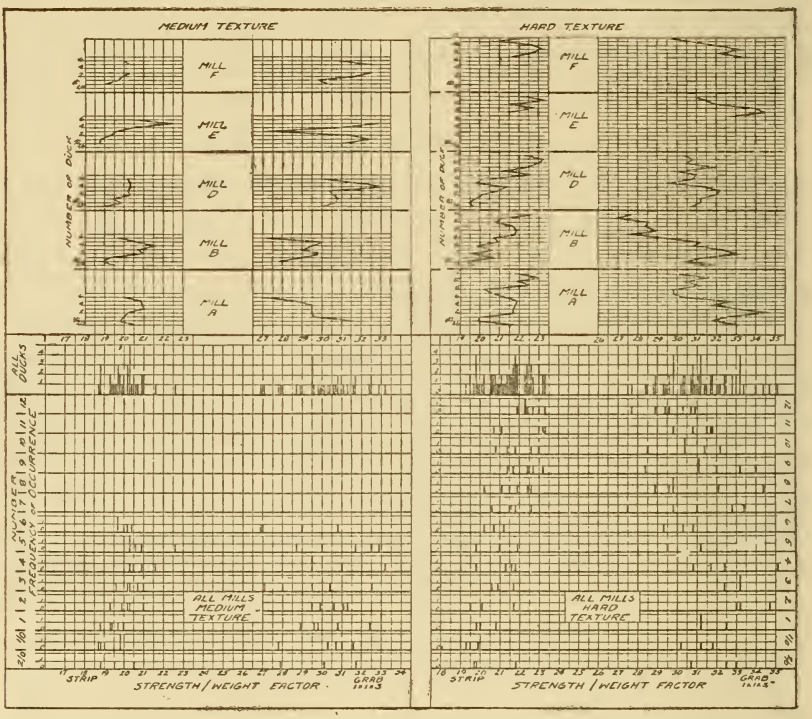

FIG. 8.—*A comparison of the strength-weight factor for the strip and the 1 by 1 by 3 inch grab methods*

The results are grouped for each number and for each mill, for both medium and hard texture numbered duck. A total frequency for all the duck is shown. The strength-weight factor is obtained by dividing the sum of the breaking strengths (in pounds) of the warp and filling by the weight per square yard (in ounces).

of the test specimen of the more highly crimped system straighten out first, causing the inside threads to carry more than their proportionate share of the load and thus lowering the breaking-strength result. In the grab test these conditions are not obtained, for the threads are held in place by the surrounding interlacings.

Consideration should be given to the strength-weight factor in selecting a method of determining breaking strength. This factor is obtained by dividing the sum of the warp and filling

breaking strength in pounds by the weight of the material in ounces per square yard.

$$\frac{\text{(Breaking strength warp)} + \text{(Breaking strength filling)}}{\text{Weight in ounces per square yard}} = \left\{\begin{matrix}\text{Strength-}\\\text{weight}\\\text{factor}\end{matrix}\right.$$

Figure 8 shows a comparison of the strength-weight factor as determined for the strip and 1 by 1 by 3 inch grab methods on both medium and hard texture ducks. The graph for each mill is shown above. Since numbered duck is manufactured on a

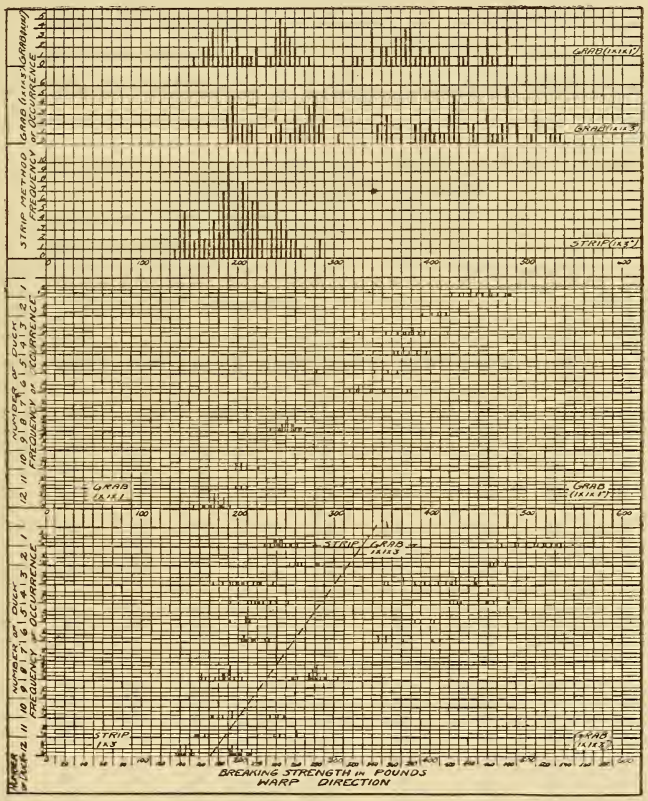

FIG. 9.—*A comparison of the strip (1 by 3 inch), grab (1 by 1 by 3 inch), and grab (1 by 1 by 1 inch) methods of determining breaking strength using the results obtained on the warp direction of numbered cotton duck*

definite system using the ply of yarns and thread count to increase weight, this increased weight should result in a proportionate increase in strength. The strength-weight factor should remain unchanged for the same texture of duck. However, if by variation of the thread count, yarns, and plies, the texture of the duck is materially altered, a variation in the strength-weight factor would result. This fact accounts for the difference in strength-weight factors for the medium and hard texture ducks.

Late in this investigation an effort was made to ascertain the relation of the 1 by 1 by 1 inch grab method to the strip and the 1 by 1 by 3 inch grab methods. A number of ducks which were then available were tested according to these three methods. The results are given in Table 7 and shown in Figure 9. The results show that the 1 by 1 by 1 inch grab method averages lower in strength than the 1 by 1 by 3 inch grab method.

The 1 by 1 by 1 inch grab method has a very objectionable feature in that if the staple length is much over 1 inch the test becomes a combination of the fiber and the material breaking strength, for some of the fibers will be held at each end by the jaws. The fabric assistance, which is a feature of the grab test, is also more or less limited in this test by the closeness of the jaws.

TABLE 7.—Results of Strip, Grab 1 by 1 by 3 Inch and Grab 1 by 1 by 1 Inch Breaking Strength Methods

Mark	Duck number	Weight per square yard	Thread count per inch		Ply		Breaking strength					
							Strip method		Grab method 1 by 1 by 1 inch		Grab method 1 by 1 by 3 inch	
			Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling	Warp	Filling
		Ounces					Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1	12	11.2	49	33	2	2	145	106	178	128	195	125
2	12	11.5	49	33	2	2	141	115	165	133	195	131
3	12	11.7	49	35	2	2	146	123	184	140	211	155
4	------	13.7	46	33	3	3	161	132	210	162	253	154
5	10	15.2	45	31	3	3	175	140	205	169	276	199
6	8	17.5	45	25½	3	4	173	159	251	207	289	193
7	8	17.5	45	25½	3	4	185	161	246	195	276	202
8	8	17.6	45	25½	3	4	185	164	257	202	273	222
9	8	17.8	45	26	3	4	191	183	256	210	387	308
10	6	21.1	36	27	3	3	209	197	316	246	354	234
11	6	21.4	36½	37½	3	3	218	210	361	260	404	278
12	5	23.4	36½	27	3	3	207	228	342	289	387	308
13	4	25.0	30	23	4	4	229	261	378	332	455	335
14	4	25.3	30	24½	4	4	225	255	362	315	450	323
15	3	25.8	30	22½	4	5	225	309	385	383	411	415
16	3	26.0	30	23	4	5	197	314	371	405	439	416
17	3	26.1	30	22	4	5	198	332	353	381	386	394
18	2	28.3	29½	21	5	5	270	243	469	281	405	286
19	1	28.7	30	21	5	5	244	224	444	370	493	375
20	1	28.8	30	21	5	5	248	224	464	355	511	370
21	1	30.5	30	21½	5	5	239	281	454	342	520	395

Considering then the facts brought out in the above discussion, it was decided that the 1 by 1 by 3 inch grab method was the most desirable method for testing the breaking strength of numbered ducks. In selecting the breaking-strength values they were figured on a strength-weight factor basis for hard-texture ducks of 27.5, and for medium-texture ducks on a factor of 26.2.

After a method and basis for the specification of breaking strength had been selected, some attention was given to determin-

ing how many tests would be necessary to obtain a fair average. The cost of making a test increases with the number of samples necessary to obtain the average, both on account of the extra time involved and the additional materials required.

Provisions had been made, as is customary, for the elimination and substitution for any breaks which for any reason due to operation fall markedly below the general average. The series of 40 test results shown in Table 8 were then obtained.

TABLE 8.—Determination of Number of Tests to Obtain the Average Breaking Strength

Break	Reading	Successive sums	Successive averages	Sum of successive 3 breaks	Average of successive 3 breaks	Sum of successive 5 breaks	Average of successive 5 breaks
	Pounds						
1	460	460	460				
2	470	930	465				
3	466	1,396	465	1,396	465		
4	480	1,876	469	1,416	472		
5	440	2,316	463	1,386	462	2,316	463
6	440	2,756	469	1,360	453	2,316	463
7	480	3,236	462	1,360	453	2,306	461
8	469	3,705	463	1,389	463	2,309	462
9	468	4,173	464	1,417	472	2,297	459
10	457	4,630	463	1,394	465	2,314	463
11	430	5,060	460	1,355	452	2,304	461
12	470	5,530	461	1,357	452	2,294	459
13	462	5,992	461	1,362	454	2,287	457
14	458	6,450	461	1,390	463	2,277	455
15	472	6,922	461	1,392	464	2,292	458
16	458	7,380	461	1,388	462	2,320	464
17	440	7,820	460	1,370	457	2,290	458
18	448	8,268	460	1,346	449	2,228	456
19	461	8,729	460	1,349	450	2,279	456
20	473	9,203	460	1,382	461	2,280	456
21	470	9,673	461	1,404	468	2,292	456
22	460	10,133	461	1,403	468	2,312	462
23	462	10,595	461	1,392	464	2,326	465
24	460	11,055	461	1,382	461	2,325	465
25	460	11,515	461	1,382	461	2,312	462
26	448	11,963	460	1,368	456	2,290	468
27	470	12,433	460	1,378	459	2,300	460
28	462	12,895	461	1,380	460	2,300	460
29	454	13,349	460	1,386	462	2,294	459
30	478	13,827	461	1,394	465	2,314	463
31	465	14,292	461	1,397	466	2,329	466
32	480	14,772	462	1,423	474	2,339	458
33	467	15,239	462	1,412	471	2,364	473
34	448	15,687	461	1,395	465	2,340	468
35	460	16,147	461	1,375	458	2,342	468
36	480	16,627	462	1,388	463	2,335	467
37	440	17,067	461	1,380	460	2,295	459
38	460	17,527	461	1,380	460	2,288	458
39	465	17,982	461	1,365	455	2,305	461
40	455	18,437	461	1,380	460	2,300	460

Under the heading "successive sums" is shown each break plus all those that preceded it. "Successive averages" show this sum divided by the number of the break, which means that 463 opposite break 10 is an average of the 10 breaks; 461 opposite break

15 is an average of 15 breaks; etc. Under "sum of successive 3 breaks" is given the sum of each break and the 2 immediately preceding it; "sum of successive 5 breaks" is the sum of each break and the 4 immediately preceding it. The "average of successive breaks" show these results divided by 3 and 5, respectively. Figure 10 shows a graph of these results and assuming that the average of 40 breaks (461) is fair, the percentage variation plus or minus is shown. The curve on the right shows how

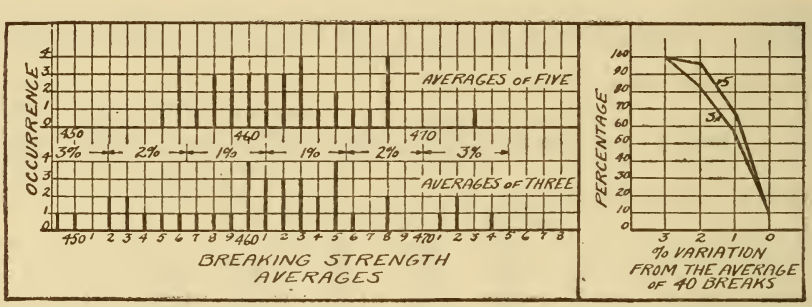

FIG. 10.—*A comparison of the averages obtained using groups of three and of five breaking strength results*

The curve shows the percentage of these averages which are included within 1 per cent, 2 per cent, and 3 per cent of the average of 40 results.

many of the averages are included in 1, 2, or 3 per cent variation from the fair average. Since over 82 per cent of the averages of 3 breaks are within 2 per cent tolerance of the average of 40 breaks, and all are within a 3 per cent tolerance, it was concluded that 3 breaks would be sufficient.

VII. SPECIFICATION FOR NUMBERED COTTON DUCK

NOTE.—The following specification, which was finally drawn up for both Government and commercial use from the data discussed in this paper, is also printed as Bureau of Standards Circular No. 136 (Federal Specifications Board Specification No. 53.) Circular No. 136 may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 5 cents.

U. S. Gov't Standard Specification, No. 53.

DEPARTMENT OF COMMERCE.

BUREAU OF STANDARDS.

George K. Burgess, Director.

CIRCULAR OF THE BUREAU OF STANDARDS, NO. 136.

(2d edition. Jan. 12, 1924.)

UNITED STATES GOVERNMENT SPECIFICATION FOR NUMBERED COTTON DUCK.[1]

FEDERAL SPECIFICATIONS BOARD.

STANDARD SPECIFICATION NO. 53.

This specification was officially adopted by the Federal Specifications Board on February 1, 1923, for the use of the Departments and Independent Establishments of the Government in the purchase of numbered cotton duck.

CONTENTS.

1. INTRODUCTION.

This specification was drawn up by the Cotton Duck Association and several of the large Government departments. The results of tests made at the Bureau of Standards were used to establish most of the tolerances and figures.

2. MATERIAL.

The duck shall be made of cotton thoroughly cleaned and free from waste. It shall be evenly woven without sizing, and shall be free from an excessive number of avoidable imperfections of manufacture.

[1] This specification was adopted by the Cotton Duck Association.

3. WEAVE.

The weave shall be plain.

4. WIDTH.

The average width shall be as specified with the following tolerances:

Widths up to and including—	Inch.
36 inches	−¼ to +¼
37 to 60 inches	−¼ to +⅜
61 to 80 inches	−⅜ to +⅝
81 to 120 inches	−⅜ to +¾

5. WEIGHT.

The requirements for weight shall be as given in the table below with a tolerance of 2½ per cent, plus or minus.

6. CONSTRUCTION AND COUNT.

The number of ply and the count (or number of threads per inch, warp and filling) shall not be uniformly less than shown in the table below. They may be exceeded in the discretion of the manufacturer. The allowable variation from the manufacturers' standard count shall not exceed, within a bolt or roll, for the WARP:

±1½ threads in fabrics counting not over 40 threads per inch;
±2 threads in fabrics counting over 40 threads per inch;

and for the FILLING:

±1 thread in fabrics counting not over 25 threads per inch;
±1½ threads in fabrics counting from 25½ to 32 threads per inch;
±2 threads in fabrics counting over 32 threads per inch.

The count shall be determined by ascertaining the number of threads in 3 inches, taken consecutively, and reducing to terms of 1 inch. The warp count shall not be taken at less than 8 inches from either selvage for goods 26 inches or more in width; for goods under 26 inches it shall not be taken nearer the selvage than one-fourth of the entire width of the fabric.

7. METHOD OF TESTING.

From each delivery of 1,000 yards or fraction thereof a sample of not more than 2 linear yards shall be cut from any part of at least two rolls for test purposes.

Tests may be made under prevailing atmospheric comditions, except in the settlement of disputes concerning weight and strength. Such tests shall then be made upon material having normal moisture content, obtained by exposure for at least four hours

to an atmosphere of 65 per cent relative humidity at 70° F. temperature.

All tests for breaking strength shall be made on an approved type of inclination balance breaking machine. The maximum capacity of the machine shall be 800 pounds.

The 1 by 1 by 3 inches grab method of testing shall be used, defined as follows: The lower half of each pair of jaws shall be 2 inches or more in width and the upper half shall be 1 inch in width. Jaws shall be planed smooth and flat with edges slightly rounded to prevent cutting. The initial length of the test pieces between the jaws of the testing machine shall be 3 inches, and the pulling jaw shall travel at a uniform rate of 12 inches per minute. Six test pieces, 6 inches long by 4 inches wide, shall be cut, three in the direction of the warp and three in the direction of the filling, respectively. Care shall be taken that no two test pieces include the same threads. The average result of the tests shall be recorded separately for warp and filling. No sample for testing shall be taken at less than 8 inches from either selvage for goods 26 inches or more in width, or for goods under 26 inches at less than one-fourth of the entire width of the fabric. If the width of the goods does not admit of cutting pieces as stated above, they shall be taken as near the center as possible.

In the case of a break evidently below the general average for the fabric, a second test on the same threads shall be made and this test shall then be used in obtaining the average result.

In the event of a dispute regarding measurements, the material shall be placed under sufficient tension to make it lie flat upon a table, or other plane surface, and exposed to an atmosphere of 65 per cent relative humidity at 70° F. temperature, and when measured under these conditions the yardage delivered shall be not less than the invoiced yardage.

8. CAUSES FOR REJECTION.

In the event of a dispute in regard to width, the average width shall be determined by measuring in not less than five places about equally distant, throughout the length of the bolt or roll. In no place shall the variation in width be more than one-eighth inch greater than the tolerance for average width specified in paragraph entitled "Width."

In the event of a dispute in regard to weight, the weight per square yard shall be determined from the nominal width, the invoiced yardage (verified when necessary), and the actual weight of

the entire bolt or roll. The results of tests on 1 or 2 yards for width and weight shall not be used alone as a basis for rejection.

No rolls or bolts running less than 10 per cent under the strength specified shall be rejected, provided the delivery in question shall average up to specifications.

No rolls or bolts shall be rejected, the combined strength of the warp and filling of which shall be equal to the combined strength specified in the table below, provided neither element is more than 10 per cent under the requirements applying to that element.

9. DEFINITION.

The terms "bolts" or "rolls" as used above are hereby defined as meaning continuous lengths averaging from 100 to 110 yards, but a roll or bolt of not less than 85 yards will constitute a good commercial delivery.

TABLE 1.—Construction, Weight, and Strength.

No. of duck.	Weight.		Width.	Distance of selvage stripe from edge.	Minimum ply.		Minimum thread count per linear inch.		Breaking strength 1 by 1 by 3 inches grab.	
	Per linear yard 22 inches wide.	Per square yard.			Warp.	Filling.	Warp.	Filling.	Warp.	Filling.
Hard texture:	Ounces.	Ounces.	Inches.	Inches.					Pounds.	Pounds.
2/0	20	32.72	As specified	2	5	7	26	18	465	435
1/0	19	31.09	do	2	5	6	26	18	450	405
1	18	29.45	do	1¾	5	5	26	19	440	370
2	17	27.82	do	1¾	5	5	27	21	420	345
3	16	26.18	do	1½	4	5	29	21	390	330
4	15	24.54	do	1½	4	4	29	22	375	300
5	14	22.90	do	1½	3	4	34	24	345	285
6	13	21.27	do	1¼	3	3	34	26	335	250
7	12	19.63	do	1¼	3	3	35	22	300	240
8	11	18.00	do	1⅛	3	3	33	23	285	210
9	10	16.36	do	1	3	3	38	25	255	195
10	9	14.72	do	1	3	3	44	26	245	160
11	8	13.08	do	1	3	2	44	32	235	125
12	7	11.45	do	1	{2 {3	2 2	48 40	34 34	} 195	120
Medium texture:										
2/0	20	32.72	do	2	5	8	26	16	450	405
1/0	19	31.09	do	2	5	6	26	16	435	380
1	18	29.45	do	1¾	5	5	26	17	425	345
2	17	27.82	do	1¾	5	5	26	16	410	320
3	16	26.18	do	1½	4	5	26	17	370	315
4	15	24.54	do	1½	4	4	28	19	350	290
5	14	22.90	do	1½	3	4	28	20	315	285
6	13	21.27	do	1¼	3	3	34	20	305	250